

Booting Up and Shutting Down

Reference: [NYCU CSCC SA Course](#)

國立成功大學資訊工程系

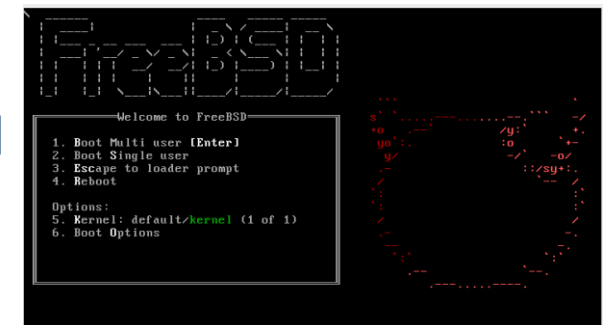
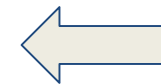
Department of Computer Science and Information Engineering, NCKU

Handbook and Manual pages

- Complete guide and be found at
 - <https://www.freebsd.org/doc/en/books/handbook/boot.html>
 - https://www.freebsd.org/doc/zh_TW/books/handbook/boot.html

Booting Overview - After Powering On

- BIOS (Basic Input/Output System) - stored on motherboard
 - Find MBR in the bootable media (disk, cd, usb stick,...)
- MBR (Master Boot Record) - stored on the first sector of disk/media
 - Record partition information of the disk
 - Load boot loader in Boot Sector (prompt if multiple choices available)
- Boot Sector - stored in the each slice (outside of usual file system)
 - Recognize FreeBSD file system. Find kernel loader under /boot
- Kernel loader - stored in main file system (all below)
 - Show booting prompt and load selected kernel
- OS Kernel
 - Initialize hardware/drivers
- Init
 - Mount filesystem, acquire DHCP, start shell, ...



MBR – Master Boot Record

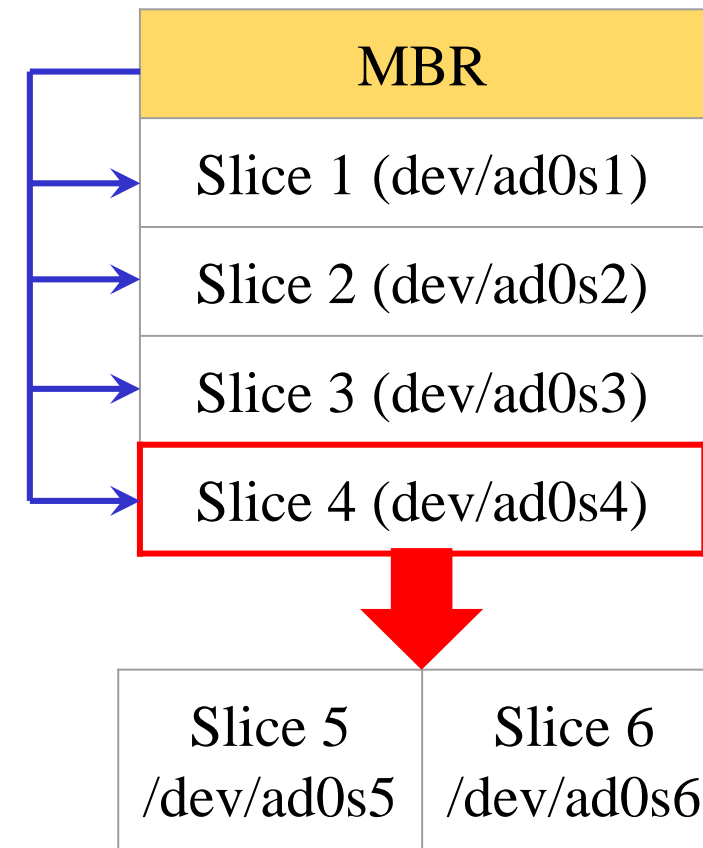
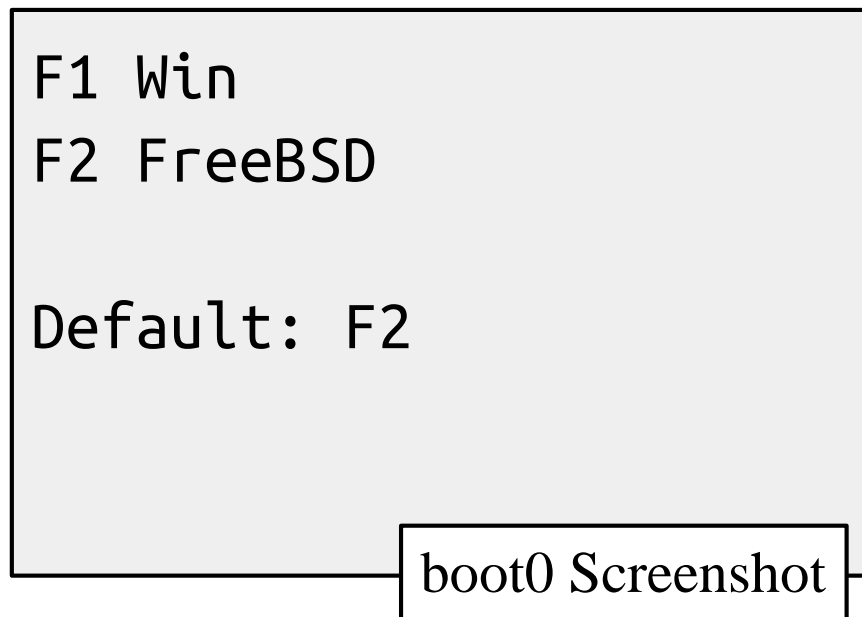
- First 512 bytes of disk, outside the FreeBSD filesystem
 - Last 2 Bytes are 0x55AA
 - Corresponding copy in FreeBSD is **/boot/boot0** or **/boot/mbr**

```
$ ls -l /boot/boot0 /boot/mbr
-r--r--r--  1 root  Wheel  512 Nov 12  2014 /boot/boot0
-r--r--r--  1 root  Wheel  512 Nov 12  2014 /boot/mbr
```

```
$ xxd /boot/mbr
00000000: fc31 c08e c08e d88e d0bc 007c be1a 7cbf  .1.....|..|.
00000010: 1a06 b9e6 01f3 a4e9 008a 31f6 bbbe 07b1  .....1.....
...
000001d0: 0000 0000 0000 0000 0000 0000 0000 0000  .....
000001e0: 0000 0000 0000 0000 0000 0000 0000 0000  .....
000001f0: 0000 0000 0000 0000 0000 0000 0000 55aa  .....U.
```

MBR – Master Boot Record

- 446 bytes - code for booting
- 64 bytes - partition table
- Responsible to find the boot code on the boot sector of bootable slice.



FreeBSD Booting Stages

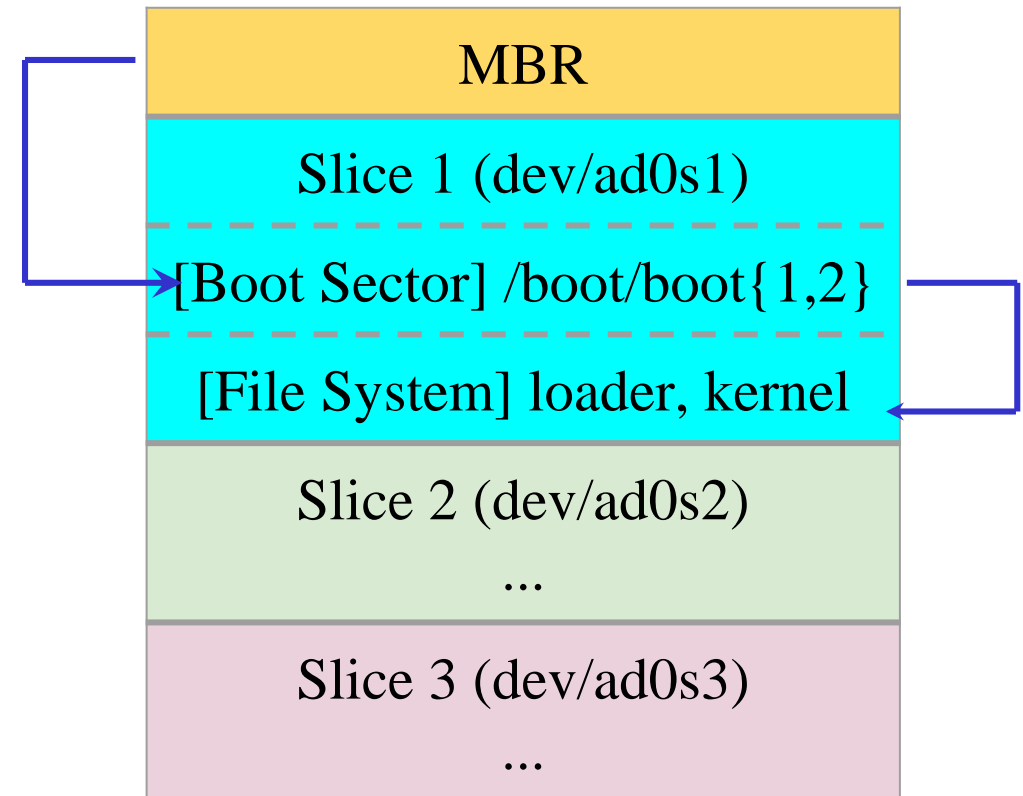
- Stage 0 (MBR)
 - /boot/mbr or /boot/boot0
 - Finds bootable partitions
- Stage 1 (Boot Sector)
 - /boot/boot1
 - Limited to 512 byte. Only recognize bsdlablel.
 - Find /boot/boot2 in somewhere of Boot Sector
- Stage 2 (Boot Sector)
 - /boot/boot2
 - Find /boot/loader or load kernel directly
- Stage 3 (BSD file system)
 - /boot/loader
 - Show prompt and load kernel

Boot Stage One and Stage Two

- boot1 and boot2 ($\text{/boot/boot1} + \text{/boot/boot2} = \text{/boot/boot}$)
 - In boot sector of given partition (outside of FreeBSD file system)
 - They belong to the same program, but divided into two parts because of space constraint
 - Copied from `/boot/boot`
 - Used to run the loader.

```
>> FreeBSD/i386 BOOT
Default: 0:ad(0,a)/boot/loader
boot:
```

boot2 Screenshot



Boot Stage Three



- Boot Stage Three: The loader
 - Provide a user-friendly interface to configure booting choice.
 - /boot/loader
 - Wait for 10 seconds then autoboot
 - Configuration
 - Kernel options, kernel modules, boot delay, ...

Default loader behavior	User-defined loader behavior
/boot/defaults/loader.conf	/boot/loader.conf

```
autoboot_delay="10"  
zfs_load="YES"
```

/boot/loader.conf

Files in /boot/

- /boot/mbr (Standard)
 - Simplified version of boot0, blindly boot the partition marked active
- /boot/boot0 (BootMgr)
 - bootmanager
- /boot/boot{ 1,2} = /boot/boot
 - boot1 is very simple, since it can only be 512 bytes in size, and knows just enough about the FreeBSD **bsdlabeled**, which stores information about the slice, to find and execute boot2.
 - boot2 is slightly more sophisticated, and **understands the FreeBSD file system enough to find files on it**, and can provide a simple interface to choose the kernel or loader to run /boot/loader
- /boot/loader
 - load the kernel from disk
- /boot/kernel/kernel

MBR recover

- If MBR is overwritten by Windows (or other OS), and you want to replace it with FreeBSD MBR:
 - Boot with FreeBSD CD/DVD or USB Drive
 - `$ fdisk -B -b /boot/boot0 ad0 or boot0cfg -B /dev/ad0`
 - -B means reinitialize the boot code contained in sector 0 of the disk
 - -b is used to specify the boot code
- If you want to replace it with Windows MBR
 - Boot with Windows CD/DVD or USB Drive
 - `C:\fdisk /mbr`

Single User Mode

- Similar to Windows "Safe Mode"
- Repair system
 - Inconsistent file system
 - Error in a boot configuration
- Reset lost root password
 - Entering single user mode **requires no password**
- Full access to local file and configuration (root permission)
- No network access

Boot in single user mode

OS	Command
FreeBSD	Interrupt the boot loader (stage 2) and type <code>"/boot/loader -s"</code> or type <code>"2"</code> in the menu of kernel loader
Linux	Lilo: <code>linux single</code> Grub: append <code>'single'</code> in the boot menu (You may need to press <code>"ESC"</code> to show Grub menu in Ubuntu.)
Solaris	Press <code>"STOP"</code> and <code>"a"</code> to enter the boot PROM and Press <code>"boot -s"</code>

Insecure single user mode

- Single user mode requires **no password** by default
 - When the physical security to the console is considerable, set console to be insecure in `/etc/ttys`

```
# name      getty                type      status      comments
#
# If console is marked "insecure", then init will ask
# for the root password
# when going to single-user mode.
# console none                    unknown off secure
console none                      unknown off insecure
```

`/etc/ttys`

Using Single User Mode

- Only the root partition is mounted and mounted as read only
 - `mount -u /`
 - Indicates that the status of an already mounted file system should be changed
 - `mount -a -t ufs` (or other external types)
 - Mount all file systems with specific type
 - `swapon -a`
 - Enable all swap

Multibooting (1)

- FreeBSD

- FreeBSD boot loader will try to detect bootable partitions
- You can also declare the bootable partitions explicitly with `boot0cfg`
 - `$ boot0cfg -B -m 0x7 ad0`
 - -m means mask, Specify slices to be enabled/disabled,
 - E.g. 0x7 means 0111, boot menu will detect slice 1~3 to show the options (and slice 4 is disabled)

Multibooting (2)

- Linux
 - Using lilo or grub

```
default 0
timeout 30
fallback 1
```

```
# For booting GNU/Linux
title GNU/Linux
kernel (hd1,0)/vmlinuz root=/dev/hdb1
```

```
# For booting FreeBSD
title FreeBSD
root (hd0,2,a)
kernel /boot/loader
```

```
# For booting Windows NT or Windows95
title Windows NT / Windows 95 boot menu
root (hd0,0)
makeactive
chainloader +1
```


Steps in the boot process

- Loading and initialization of the kernel
- Device detection and configuration
- Creation of spontaneous system processes
- Execution of system startup scripts
- Multiuser operation

Steps in the boot process – Kernel initialization

- Get kernel image into memory to be executed
- Perform memory test
 - Allocate internal data structures of kernel

OS	Kernel Image Path
FreeBSD	/boot/kernel/kernel
Linux	/boot/vmlinuz
Solaris	/kernel/genunix
SunOS	/vmunix

Steps in the boot process – Hardware configuration

- Devices specified in kernel configuration file
 - Kernel will try to locate and initialize it
- Devices not specified in kernel configuration file
 - Kernel tries to determine other information by probing the bus
 - If the driver is missing or not responsible to the probe, device is disabled
 - We can load kernel module to support this device.
 - kldload, kldstat, kldunload
 - /boot/kernel/*.ko

```
if_em_load="YES"  
vboxdrv_load="YES"  
vboxnet_enable="YES"
```

/boot/loader.conf

Steps in the boot process – System Processes

- Spontaneous process
- Not created by the normal UNIX fork mechanism

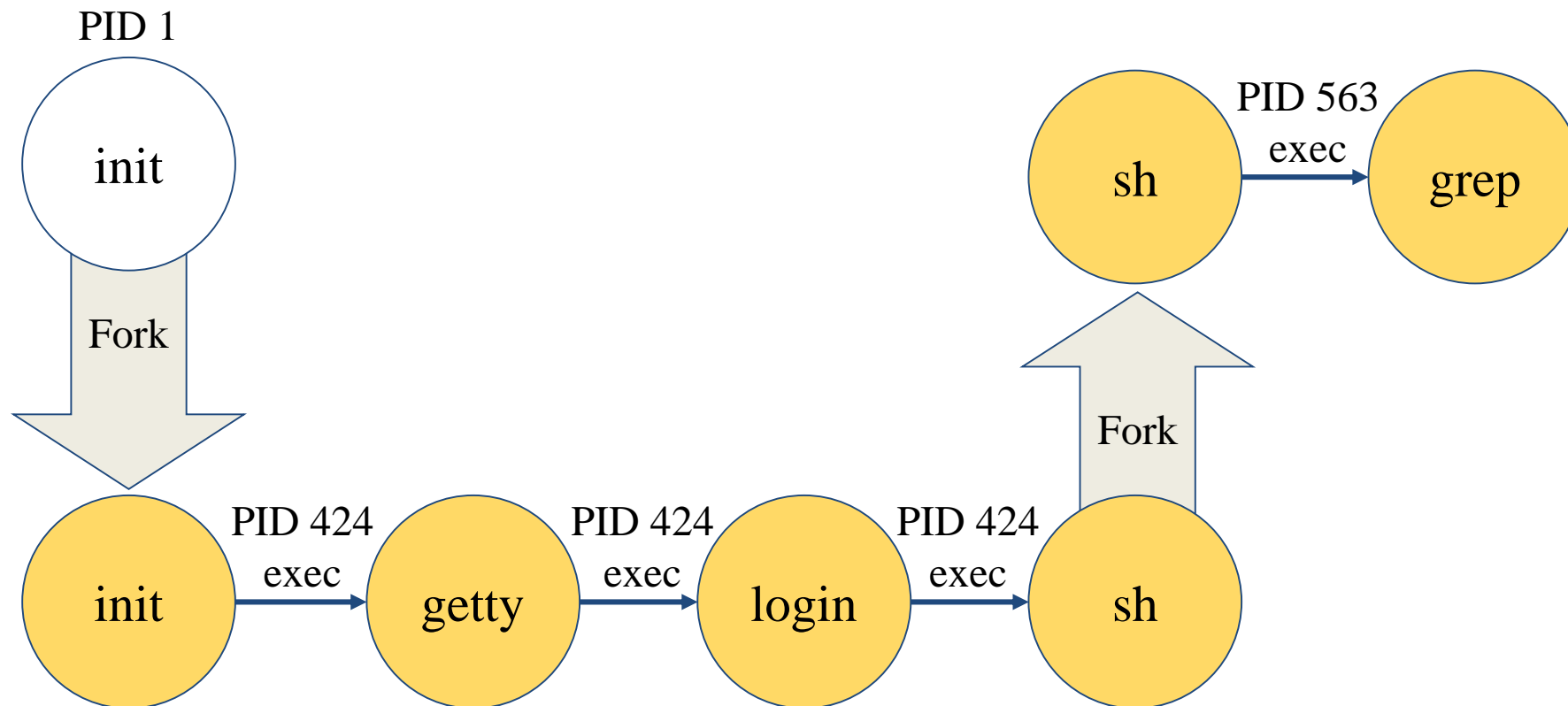
OS	Pid 0	Pid 1	Pid 2 and more
FreeBSD	kernel	init	g_event
Linux	-	init	kthreadd, kflushed,kupdate kpiod,kswapd
SunOS	sched	init	pageout

Steps in the boot process – Execution of startup scripts

- The startup scripts are selected and run by init
- Typical works are:
 - Setting the name of the computer
 - Setting the time zone
 - Checking the disk with fsck
 - Mounting the system's disks
 - Removing files from /tmp directory
 - Configuring network interface
 - Starting up daemons and network services

Steps in the boot process – Multiuser operation

- From now on, the system is fully operational, but no one can login
 - init will spawn getty processes to listen for login



FreeBSD startup scripts

- The BSD-style booting
- init will run /etc/rc
- /etc/rc will reads the following configuration
 - /etc/defaults/rc.conf
 - /etc/rc.conf
 - /etc/rc.d
- [rc\(8\)](#)

Ways to shutdown or reboot

- Turn off the power ← Please Don't
- Use the [shutdown\(8\)](#) command
 - Or using the halt and reboot command
 - halt = shutdown -h
 - reboot = shutdown -r

Ways to shutdown or reboot – shutdown command

OS	Pathname	Time	Reboot	Halt	Single User Mode	Skip Fsck
FreeBSD	/sbin/shutdown	time	-r	-h		
Linux	/sbin/shutdown	time	-r	-h		
Solaris	/usr/sbin/shutdown	-gsecs	-i6	-i0	-is	
SunOS	/usr/sbin/shutdown	+mins	-r	-h		-f

- Time format can be
 - +m
 - hh:mm => Linux
 - yymmddhhmm => FreeBSD

Halt ? Poweroff ?

- Halt

- Terminate all processes, write data back to disks
- When everything is ready, tell user to turn off the power
 - Or reboot by pressing any key
- In older systems, you need to manually do so

```
The operating system has halted.  
Please press any key to reboot.
```

It's now safe to turn off
your computer.

您現在可以放心關機

Poweroff

- Halt + Turn off the power
- ACPI / APM
 - Advanced Configuration and Power Interface
 - Advanced Power Management
- In FreeBSD
 - Try “shutdown -p now” (or **poweroff**)

In case it does not work...

1. Compile this into kernel
 - device apm0 at nexus?flag 0x20
2. Rebuild the kernel
3. Edit /etc/rc.conf
 - apm_enable="YES"
 - apmd_enable="YES"
4. Reboot
5. Try “shtudown -p now” (or poweroff)

Other Booting Manager

- Besides BSD-style booting, another line is System-V
 - Used by many Linux distributions
 - Solaris, Debian

System-V Startup Scripts

- Run-level
 - /etc/inittab
 - init follow the inittab from level 0 to level k
- Example: inittab in sun1

Run Level	Startup scripts	Meaning
0	/etc/rc.d/rc0.d/	Halt
1	/etc/rc.d/rc1.d/	Single user mode
2	/etc/rc.d/rc2.d/	Multiuser without NFS
3	/etc/rc.d/rc3.d/	Full multiuser mode
4	/etc/rc.d/rc4.d/	User defined
5	/etc/rc.d/rc5.d/	Multiuser with graphical interface
6	/etc/rc.d/rc6.d/	Reboot

Ways to shutdown or reboot – telinit

- Only for SystemV systems (and Systemd)
- telinit: change run-level
- Halt/poweroff
 - `$ telinit 0`
- Reboot
 - `$ telinit 6`
- Single user mode
 - `$ telinit 1`

Systemd

- Modern system/service manager for many Linux distributions
 - Ubuntu, Debian, ...
- Evolved from System-V
 - Another booting manager beside BSD
 - Used by older versions of Linux distributions
 - Debian < 8.0 : System-V
 - Debian >= 8.0 : Systemd
- Similar to System-V, but faster and easier to use

Systemd

- Use 'targets' to replace run-levels

SysV Run Level	Systemd targets	Meaning
0	runlevel0.target, poweroff.target	Poweroff
1	runlevel1.target, rescue.target	Single user mode
2	runlevel2.target, multi-user.target	User defined. Default: same as level 3
3	runlevel3.target, multi-user.target	Multiuser mode
4	runlevel4.target, multi-user.target	User defined. Default: same as level 3
5	runlevel5.target, graphical.target	Multiuser with graphical interface
6	runlevel6.target, reboot.target	Reboot